UNIVERSITY OF CINCINNATI

Bulletin No. VII

SERIES II Publications of the University of Cincinnati VOL. II
SCIENTIFIC AND LITERARY

QUESTIONS WITH μή AND ἆρα μή

BY

J. E. HARRY

The University Bulletins are Issued Quarterly

Entered at the Post Office at Cincinnati, Ohio, as second-class matter

UNIVERSITY PRESS
Cincinnati, Ohio

Reprinted from Studies in Honor of Basil Lanneau Gildersleeve.

INDICATIVE QUESTIONS WITH μή AND ἆρα μή.[1]

The first half of section 1603 of Goodwin's grammar reads as follows: "The principal direct interrogative particles are ἆρα and (chiefly poetic) ἦ. These imply nothing as to the answer expected; but ἆρα οὐ implies an affirmative answer and ἆρα μή a negative answer." The form of these statements leads one to believe that ἆρα μή is a common prose construction, and, consequently, that the number of examples of ἆρα μή in classical prose exceeds the number of ἦ's, whereas just the reverse is true. In section 1015 of Hadley-Allen the sentence ἆρα μὴ διαβάλλεσθαι δόξεις; is cited without a hint as to the extent of the use of ἆρα μή either in prose or poetry. Kühner, 587, 11, speaks only of μή and has only three words on this: "erst seit Aeschylus," though to be sure, in 587, 14, he says that ἆρα occurs "erst in der nachhomerischen Sprache." All other grammars, both German and English, are as silent on this subject as Kühner. The lexicons either furnish little information or are misleading. (Cf. Amer. Journ. of Philol. III, 515 and XIX, 233.) Commentaries show as little sense of proportion in respect to the usage of these interrogative particles as the grammarians.

Dyer on Apology 25 A remarks that "questions with μή take a neg. answer for granted," and on Crito 44 E "ἆρα μή looks for a neg. answer, but it may also convey an insinuation that in spite of the expected denial the facts really would justify an affirmative answer." There is no intimation of the limitations of both μή and ἆρα μή. On ἆρα μή in Memorabilia II, 6, 34 Winans has nothing to say; on IV, 2, 10 he refers to the grammars of Goodwin and Hadley; and on μή in IV, 2, 12 to Goodwin's Moods and Tenses 46 n. 4,

[1] My attention was first directed to this subject by Dr. C. W. E. Miller, who pointed out to me the rare use of μή (ἆρα μή) as an interrogative particle in Classical Greek, and told me that as the result of observations in this direction he felt certain that, with the exception of perhaps a solitary example in Demosthenes, the construction was not found in the Attic orators, and that Plato was about the only prose writer that employed it to any noteworthy extent.—J. E. H.

where, he remarks, "another interpretation is given, however, reading δύναμαι with Kühn. and several MSS." But Goodwin reads δύνωμαι in the edition of 1890 (268).

With the exception of three examples in Xenophon, ἆρα μή does not occur in prose outside of Plato; and in the 2442 pages of the extant works of this author (Teubner text) only ten examples of the construction are found, two of these being in spurious dialogues (Anterastae and De Virtute). The Phaedo contains three of the remainder; two of these may be counted as one—64 C, where ἆρα μὴ ἄλλο τι ᾖ is used and then repeated in toto in resuming the question; the third is found in 103 C. The remaining five are distributed as follows: Crito 44 E, Parmenides 163 C, Charmides 174 A, Lysis 213 D, Republic 405 A. The indicative is used in all the examples except the second one of Phaedo 64 C, which has the subjunctive, like the examples of simple μή in cautious questions.[1]

The frequency of occurrence of the interrogative particle ἆρα, alone and combined with οὐ, γε, οὖν and μή, in the dialogues of Plato may be seen from the following conspectus:

	ἆρα	ἆρά γε	ἆρ' οὖν	ἆρ' οὐ	Total.	ἆρα μή
Euthyphro[2] .	7	1	3	4	14	. .
Apology .	2	. .	1	. .	3	. .
Crito . .	3	1	1	1	6	1
Phaedo . .	13	. .	9	13	33	3
Cratylus .	11	2	12	19	41	. .
Theaetetus .	25	. .	11	11	44	. .
Sophistes . .	15	. .	6	29	48	. .
Politicus . .	13	1	8	17	38	. .
Parmenides .	13	2	20	26	55	1
Philebus . .	18	. .	21	28	65	. .
Symposium .	5	1	3	. .	9	. .
Phaedrus . .	1	1	6	9	13	. .
Alcibiades I .	17	. .	13	6	34	. .
Alcibiades II .	2	3	7	5	16	. .

[1] Goodwin (M T 268) and Weber cite all the examples except Cratylus 429 C μὴ γὰρ οὐδὲ τοῦτο αὖ ᾖ, τὸ τοῦτον φάναι Ἑρμογένη εἶναι, εἰ μή ἐστιν;

[2] ἆρ' οὖν οὐ (14 D) is counted twice. Hence the apparent mistake in the total column. So also in Leges and De Virtute.

	ἆρα	ἆρά γε	ἆρ' οὖν	ἆρ' οὐ	Total.	ἆρα μή
Hipparchus .	4	. .	2	. .	6	. .
Anterastae .	1	. .	3	1	5	1
Theages . .	2	2	. .	4	8	. .
Charmides .	5	1	3	2	11	1
Laches . .	4	. .	. .	1	5	. .
Lysis . .	9	1	10	2	21	1
Euthydemus .	13	2	13	2	30	. .
Protagoras .	11	. .	7	8	26	. .
Gorgias . .	27	. .	22	1	50	. .
Meno . .	11	. .	5	6	21	. .
Hippias Maior.	4	. .	8	6	16	. .
Hippias Minor.	2	. .	2	2	5	. .
Ion . .	2	. .	. .	. .	2	. .
Republic .	42	4	95	81	190	1
Timaeus .	1	. .	3	3	6	. .
Minos . .	1	. .	2	2	5	. .
Leges . .	29	4	33	59	113	. .
Epinomis .	1	. .	. .	3	4	. .
Epistolae .	2	1	1	. .	4	. .
De Iustitia .	1	1	. .	6	8	. .
De Virtute .	3	. .	3	1	6	1
Demodocus .	1	. .	1	. .	2	. .
Sisyphus .	3	3	3	2	11	. .
Alcyon .	. .	1	. .	. .	1	. .
Eryxias .	10	4	5	. .	19	. .
	334	36	342	360	994	10

It will be seen from the table that ἆρα, ἆρ' οὖν and ἆρ' οὐ nearly balance each other; there are nearly twice as many examples of ἆρα as of ἆρ' οὐ, and only one out of every hundred of the ἆρα's is followed by μή.

There are 104 examples of ἆρα in the orators (including both genuine and spurious speeches). Of these 22 are followed by οὐ. Ἆρά γε appears 17 times and ἆρ' οὖν 23. Demosthenes has a greater number of ἆρα's than all the others together (64); half of them are found in orations XVIII–XXIV; and ten are followed by οὐ. There is little variation in the figures for the rest of the orators (except Antiphon, in whom the particle does not occur),

Andocides having two examples (both without *οὐ*), Lysias seven (one negative), Isocrates five (one neg.), Isaeus five (one neg.), Lycurgus six (three negatives), Aeschines five (one neg.), Hyperides four (all neg.), Dinarchus four (no negatives).

In the historians *ἆρα* hardly makes its appearance—twice in Herodotus (*ἆρα* III, 50; *ἆρ' οὐ* IX, 27) and only once in Thucydides (I, 75, 1, where *ἆρα* = *ἆρ' οὐ*, as in Sophocles, O. C. 753, 780, Aristophanes, Birds 797).

Xenophon has 90 examples of *ἆρα* [36 of simple *ἆρα*, 15 of *ἆρ' οὐ*, 2 of *ἆρα μή*, 26 of *ἆρ' οὖν* (including one *ἆρ' οὖν . . . μή*), and 11 of *ἆρά γε*]. More than half of these (48) occur in the Memorabilia. The rest appear as follows: Anab. 4, Cyropaed. 18, Hellen. 1, minor works 19. Of the 15 examples of *ἆρ' οὐ*, eight belong to the Memorabilia, three to the Anabasis, one to the Cyropaedia and three to the minor works. Ten examples of the combination *ἆρ' ἄν* (followed by the optative) are found in the Cyropaedia alone. The references for the three instances of *ἆρα μή* are Mem. II, 6, 34; IV, 2, 10; and Anab. VII, 6, 5.

Interrogative *μή* occurs neither in the orators[1] nor in the historians. Even *μῶν*, which is commoner in Plato than *μή* and must be regarded as differing from *μὴ οὖν* (*μῶν μή*, *μῶν οὐ* and *μῶν οὖν* are not rare), does not appear in the orators, historians or Xenophon.

There are twenty-four examples of *μή* interrogative in Plato. Of these the greatest number is in the Republic (6); the Protagoras comes next with five; two each are found in Euthydemus, Gorgias, Meno, and Apology; one each in Phaedo and Hippias Major, and three in the Theaetetus (not counting the repetition in 146 E). In Meno 89 C (*μὴ τοῦτο οὐ καλῶς ὡμολογήσαμεν;*) *οὐ* and *καλῶς* coalesce, as does *οὐ* and *τοιαύτην* in Protagoras 312 A *μὴ οὐ τοιαύτην ὑπολαμβάνεις σου τὴν μάθησιν ἔσεσθαι*; (which, however, Goodwin considers declarative). Over against these 24 examples of *μή* there are 83 instances of *μῶν*, which include 28 occurrences of *μῶν οὐ*, 5 of *μῶν μή*, and 18 of *μῶν οὖν*, this last embracing 8 instances of *μῶν οὖν οὐ*.

[1] There is an example of *μή* with the past indic. in Dem. XX, 160 (*τί; μὴ καὶ τὰ μέλλοντ' ᾔδεις;*), but the passage is possibly corrupt. The form of the rhetorical *ὑποφορά* immediately following indicates that the preceding question was not put as it appears in our MSS. Many readings suggest themselves, e. g. *τί δεῖ καὶ τὰ μέλλοντ' ἤδη ;*

All the questions introduced by μή in Xenophon occur in Memorabilia IV, 2, 10 (except one in III, 11, 4 μὴ χειροτέχναι τινές;), and the four found here are merely a continuation of Socrates' question Ἆρα μὴ ἰατρός (sc. βούλει, or ἐπιθυμεῖς, γενέσθαι);[1] μῶν, as has been stated above, does not occur in Xenophon.

So much for the classical prose writers. Let us now direct our attention to the poets. Though ἆρα μή is, as we have seen, rare in prose, it is still rarer in poetry, there being only three examples in the whole range of epic, lyric and dramatic literature. No instance can be cited from Homer; none from the melic poets; none from Aristophanes. It appears twice in Sophocles (El. 446, Ant. 632) and once in Aeschylus (Septem 208). As for ἆρ' οὐ, Aeschylus has not a single example, Sophocles but three, Euripides five, whereas Plato has 360. Simple ἆρα occurs ten times in Aeschylus; there are 38 examples in Sophocles and 52 in Euripides—just 100 in all. There are 48 ἆρα's (seven of these followed by οὐ) in Aristophanes, but, as has been stated, not a single ἆρα μή.

Simple μή (without a preceding interrogative particle) is not found before Aeschylus, and in all the tragic poets occurs but six times, four of these being in Aeschylus (P. V. 247, 959, Pers. 344, Suppl. 295), one in Sophocles (Trach. 316),[2] one in Euripides (Hipp. 799). In Aristophanes there is but one example, and that is found in the brogue of the Scythian archer (Thesm. 1114 σκέψαι τὸ κύστο· μή τι μικτὸν παίνεται;). The compound μῶν, on the other hand, (used only by the Attic writers), can not be classed with μή, for, although it is not employed by any prose writer except Plato, the particle occurs frequently in comedy (27 examples in Aristophanes) as well as in tragedy (41 examples). The fact that μῶν occurs 33 times in Euripides and only five and three times in Sophocles and Aeschylus respectively (together with its use in comedy and its absence from the orators and historians) seems to indicate that it belongs to the *sermo familiaris*.

[1]There is another example in the Oeconomicus (XII, 1 μή σε κατακωλύω ἀπιέναι ἤδη βουλόμενον;). This may, however, be taken as a hortatory subjunctive, and so Holden explains (although in his text the sentence is interrogative), translating "let me not detain you," and referring to Goodwin 253 (1344). Kühner and Dindorf regard the sentence as a question. In Mem. IV, 2, 12 μὴ οὖν . . . οὐ δύνωμαι κτἑ. the mood is the subjunctive.

[2] The verb in this passage is unexpressed.

Μῶν οὖν is found twice in Aeschylus and once in Euripides; μῶν οὐ occurs but twice in the tragic poets (Eur. Med. 733, Troad. 714), μῶν μή not at all.

The interrogative ἦ occurs, of course, much more frequently in the tragic poets than in prose (25 times in Aeschylus, 61 times in Sophocles, and 74 times in Euripides). Aristophanes again comes near the prose norm with hardly a dozen examples.

If I can trust to a rapid reading of Aristotle, neither μή nor ἆρα μή appears in his writings. The same may be said of Callimachus, Apollonius Rhodius, Lycophron, Theocritus, Bion, Moschus, Polybius, and Diodorus Siculus (2043 Teubner pages).[1]

In Theophrastus ἆρα μή does not occur at all and μή is found but once, and that in one of the Characters (Περὶ Λογοποιίας), where the author is giving a sample of ordinary small talk, and puts in the mouth of his character the words μὴ λέγεταί καινότερον; Immediately thereafter Foss would read μὴ ἀγαθά γέ ἐστι τὰ λεγόμενα; but the MSS have καὶ μὴν instead of μή.

Yet in spite of the fact that in the whole domain of Greek literature, from Homer down to the time of Christ, a period of one thousand years, ἆρα μή appears but three times in poetry and 11 (13) times in prose, a celebrated scholar (Blaydes) desires to emend a perfectly intelligible sentence in Sophocles ἆρά μου μέμνησθε; (O. T. 1401) so as to read ἆρα μὴ μέμνησθε;

When we come to the New Testament we have a different story to tell: μή in questions is common—eight times in Matthew, four in Mark, six in Luke, twenty-one in John, four in James, eight in Romans, fourteen in I Corinthians and four in II Corinthians. All of these are with the indicative. The sum total, then, of questions with μή in the New Testament is sixty-nine, a greater number than in all the prose and poetry of the ten centuries preceding.

All the examples of μή in the New Testament are found in eight books, the four gospels containing more than half of the whole number (39). About one-third of the number (21) are in John alone. In about one-half of the cases (32) the verb is one of the

[1]Not unlike the behavior of ἆρα μή is that of ἄλλο τι and ἄλλο τι ἤ. These phrases do not appear to any extent outside of Plato. There is not a single example in the orators except Lysias (two instances only, one of these in a genuine speech and supporting the thesis that the phrase belongs to the language of everyday life, the other in a spurious speech) and the unrhetorical orator, Andocides.

three that are most common in the speech of everyday life (*be, can, have*). An even dozen of the μή's appear in the form of μή τι. The double negative μὴ οὐ is found in Romans x, 18. The negative οὐχί is very frequently the introductory word of a sentence; and ἆρά γε is found in Acts viii, 30.

The behavior of the particles in later Greek is similar to their conduct in the pre-Christian period. Dionysius of Halicarnassus, who sought to revive a true standard of Attic prose, has not a single example of either. In Plutarch (3670 pages in the Teubner text) ἆρα μή does not occur (though ἆρα alone does), μή only once, Alexander XXVIII μή τι σὺ τοιοῦτον ὁ τοῦ Διός;

In the sophist Dio Chrysostomus we find two examples of ἆρα μή and six of μή: XXXII (683 R) ἆρά γε μὴ Λακεδαιμονίους μιμεῖσθε; LVII (296 R) ἆρα μὴ ἀλαζόνα πεποίηκε τὸν Νέστορα; IX (294 R) μὴ οὖν θαυμάζουσιν αὐτόν; X (306 R) μὴ γὰρ ἐκεῖνος ἔλυσε τὸ αἴνιγμα; XIV (438 R) μὴ οὖν σὺ φῂς ἐλεύθερον εἶναι τὸν ἄνδρα τοῦτον; XXX (548 R) ἀλλὰ μή τι ὑμᾶς ἐλύπει; XXXII (676 R) μὴ τὰ ὦτα ἐπαλήλιπται τῶν ἐκεῖ; LVIII (301 R) μὴ οὖν αὐτός γε αἱρεῖ;[1]

Even Lucian, in spite of the fact that he wrote the best Attic prose that had been written for four hundred years, is not faultless. He uses μή for οὐ; but this should not surprise us, as he was a man free from affectation and would naturally use the language as it was spoken, so far as he could without being rude.[2] But Lucian is not fonder of the μή construction in questions than Dio Chrysostomus, and in the 1301 pages of the Teubner edition not a single example of ἆρα μή can be found. μή occurs only eight (really seven) times, as follows: μὴ ὀνείρων ὑποκριτάς τινας ἡμᾶς ὑπείληφεν; (Ἐνύπνιον I, 22 R.), Ἀλλὰ μὴ ὄνειρος καὶ ταῦτά ἐστιν; (Ὄνειρος II, 706), σὺ δὲ μὴ καὶ τὸν Σωκράτην αὐτὸν καὶ τὸν Πλάτωνα εἶδες ἐν τοῖς νεκροῖς; (Φιλοψευδής III, 52), Ἀλλὰ μὴ Ἑρμαφρόδιτος εἶ; . . . μὴ οὖν καὶ σὺ τοιοῦτόν τι πέπονθας; (Ἑταιρικοὶ Λόγοι III, 291), μή τι τὸν παιδοτρίβην Διότιμον λέγεις; (Ibid. 305), μή τι διήμαρτες βαλών; (Ψευδοσοφιστής III, 571), and one in the Pseudo-Lucianic dialogue Φιλοπατρίς (III, 597), μὴ τὴν τετρακτὺν φῂς τὴν Πυθαγόρου; The particles μῶν, ἆρα and ἆρ' οὖν are found occasionally.

[1] Dindorf brackets the passage in which ἆρα μή with the subjunctive occurs (XXVI, 524 R). Dio does not write as good Attic as Niebuhr would have us believe. See Amer. Journ. of Philol. I, 48, 50, 53, 57.

[2] See A. J. P. I, 47.

Of the writers of the third century A. D. I selected Plotinus and Philostratus for investigation. The chief representative of Neo-Platonism uses ἆρα, ἆρά γε and ἆρ' οὐ, but never μή or ἆρα μή. In Philostratus are found μῶν, ἆρα, ἆρ' οὐ and ἦ; and two examples of μή: Ap. V, 33 μὴ μεῖζόν τι τούτων; V, 34 μή τι τοῖς εἰρημένοις προστίθῃς; In the thirty-ninth epistle another question (Μηδὲ γράφειν φυγάδα ἀνέξῃ;) might be added to the number.

University of Cincinnati. J. E. Harry.

UNIVERSITY OF CINCINNATI

Bulletin No. 4
October, 1901

Publications of the University of Cincinnati
SERIES II VOL. I

Observations on the Efferent Neurones in the Electric Lobes of Torpedo Occidentalis —

SHINKISHI HATAI

CIVITATIS CINCINNATORUM UNIVERSITAS MDCCCLXX.
ALTA PETIT.

The University Bulletins are Issued Quarterly

Entered at the Post Office at Cincinnati, Ohio, as second-class matter

UNIVERSITY PRESS
Cincinnati, Ohio

OBSERVATIONS ON THE EFFERENT NEURONES IN THE ELECTRIC LOBES OF TORPEDO OCCIDENTALIS.

By Shinkishi Hatai,
(From the Biological Laboratory of the University of Cincinnati.)

Contents.

I. Materials used and technique employed in the present investigation.

For the present investigation, the efferent neurones in the electric lobes of *Torpedo occidentalis*, and the spinal ganglion cells from the mid-cervical ganglia of the adult white rat were used. The body weight of the rat was 141 grams. The torpedo material, which was generously furnished by Dr. Ayers, had been preserved with 10% formaline. To prepare this, a thin piece was cut from the lobe and transferred to distilled water for about six hours in order to remove all the formaline. After thorough washing with water, the material was transferred to 35% alcohol, where it remained about one hour, and then it was carried through graded alcohols and imbedded in paraffine in the usual way. The sections were cut 12 μ in thickness. For staining, a saturated aqueous solution of toluidin blue, and for contrast staining, an alcohol solution of erythrosin, were used.

The spinal ganglion of the white rat was preserved with the author's own mixture (formaline-acetic sublimate mixture) (*), and for staining, the reagents just mentioned were used.

II. Finer structure of the efferent neurones of the electric lobes in Torpedo occidentalis.

The efferent neurones of the electric lobes of *Torpedo occidentalis* are so large, more than 0.1 mm. in diameter, that they can easily be seen with the naked eye. Under moderate magnification, the cell bodies show numerous dendritic processes and the single axone is also visible in most cases.

The general form of the cell body is somewhat similar to that of the motor cells in the ventral horn of the spinal cord in man and the higher mammals. In most cases, the nucleus lies on the side of the cell-body towards the axis-cylinder process. The nucleus is nearly spherical, and very large in size proportionately to the cell-body (40–30 μ). The arrangement of the chromosomes in the nucleus is somewhat peculiar. They do not show minute spherules suspended in the delicate meshwork of the linin substance, but instead of that, irregular large masses which fill up meshes of the linin.

The nucleolus is always visible and lies at one pole of the nucleus. Curiously enough, the nucleolus, as a rule, lies in the same relative position in all the cells of a given section.

Under the higher magnification, the internal structure of the cell-body shows a fibrillar arrangement of the cytoplasm. The nature of this fibrillar structure will be discussed later on. In this chapter, only the general arrangements of these fibrils will be described.

Briefly speaking, the cell-body, except the nucleus presents everywhere a fibrillar arrangement of the cytoplasm. The following descriptions apply to the serial sections of one cell (102 μ in diameter, and 60 μ in thickness), and give a general idea of the structure above mentioned.

(*) Hatai, S.— Finer structure of the spinal ganglion cells in the white rat.—Jour. of Comp. Neurology, Vol. XI, No. 1, 1901.

Fig. 1 is a section passing through the periphery of the cell-body. In this figure, the dendritic processes are shown, but not the neuraxone. The position where the neuraxone will arise in the sections is marked by *A*. The fibrillar bundles which come from all dendritic processes of one side of the cell-body (*a*) take a curving course toward the axone hillock, thus forming an arrangement like an inverted U. Other fibrillar bundles come also from the dendrites on the other side (*b*) and take the same course toward the neuraxone. The dotted areas are interpreted as the cross-sections of the similar fibrillar bundles which, running through the cell-body in different directions, are therefore cut at different angles. In this figure, the fibrillar bundles connecting the dendrites with each other are shown very poorly.

Fig. 2 is the section nearer the center of the cell-body and follows Fig. 1. In this figure, the four dendrites are shown clearly, and the localities of the neuraxone is indicated by "*A*," although it does not appear at this level. The fibrillar bundles which form the neuraxone come from each of the dendrites. The dendrites themselves have close relations with each other by means of the connecting fibrillar bundles passing between them. The nucleus is surrounded by the fibrils coming from one of the dendrites (*c*). The fibrillar bundles which come from the dendrites (*d*) also take a part in investing the nucleus. The cross-sections of the fibrillar bundles show as clearly separated groups.

Fig. 3 is a section passing through the middle of the nucleus and follows Fig. 2. In this figure, the nucleolus is visible. The fibrillar arrangements are slightly different from those in the figures already given. In this section the fibrils do not form large bundles, but are divided into smaller strands and interwoven. The intimate connections between the dendrites are clearly shown. The nucleus is also surrounded by the bundles of the fibrils, which come from some of the dendrites. As a rule, in this level the fibrillar bundles near the nucleus are short, because bundles are, for the most part, cut more or less at right angles to their long axis. This suggests that the fibrillar bundles converge towards the nucleus. The peculiar arrangement of the fibrils near the

nucleus has been described as "vortex" or "spiral," or sometimes "Gitterähnliche Anordnung." On the contrary, the fibrillar bundles at the periphery present comparatively long sections. In this section, the neuraxone is not yet shown.

Fig. 4 is a section of the cell-body at another level. In this figure, three dendrites, nucleus, and neuraxone are clearly shown. The neuraxone "*A*" lies at one corner of the base of the rectangular cell-body. An intimate connection of each dendrite with that of the other, and also of all the dendrites with neuraxone is clearly shown in this figure. A curious arrangement of the fibrils is noticeable very near the axone hillock, where the fibrillar bundles have a beautiful spiral arrangement. This spiral arrangement is produced by the fibrils coming from various dendrites as is shown in the illustration. In this figure, connecting fibrils between the dendrites (*a*) and (*c*) are shown very clearly.

Fig. 5 is a section passing through the periphery of the side opposite to that shown in Fig. 1. In this figure, four dendritic processes are plainly shown — one from each corner of a somewhat rectangular-shaped cell-body. The position from where the neuraxone will arise in other section is marked by "*A*." A clear oblong space near the center of the cell-body is the place where the nucleus lies in the other sections. The fibrillar bundles which come from the dendrite (*a*) run towards the dendrites (*c*, *d*) along the one side of the nucleus, and finally enter the dendrites (*c*, *d*). Along the course, a few small fibrillar bundles diverge towards the periphery of the cell-body. The fibrillar bundles which come from the dendrites (*b*) run toward the dendrites (*c*, *d*) in a somewhat similar manner to those from the dendrite (*a*). In this case, the fibrillar bundles divide into two branches at the nucleus and after encircling the nucleus, they enter in the dendrites (*c*, *d*) and become continuous with those from the dendrite (*a*). From the base of the dendrite (*b*), small fibrillar bundles are distributed toward the neuraxone. From the dendrites *c*, *d*, the bundles of fibrils arise, and run toward the neuraxone. Along their course, these bundles are increased by the addition of numerous bundles of fibrils which come

from the periphery of the cell-body to form the yet larger bundles found in the axone hillock. The dendrites *a* and *b* are subdivided into two branches. In this case the branches are also connected by a few fibrils. These branches which are divided from the main dendrites (*a*, *b*,) receive fibrils from various regions of the cell-body.

From the above description, two important relations are evident: (1) That each dendrite is connected by the fibrillar bundles with several and possibly all the others, and (2) in each case, the nucleus is partially surrounded or encircled by the fibrillar bundles, on their way from the dendrites to enter into the neuraxone.

As a rule, the fibrils in the dendrites are very conspicuous, presenting long continuous lines, while in the cell-body they take tortuous or irregular courses, so that the cross-section of the cell-body presents minutely dotted areas, representing the cross-section of the bundles. From this, it is inferred that the entire course of some of the bundles must be very complex.

Fig. 6 is a diagram reconstructed from the serial sections of the cell-body in order to depict schematically its structure and to show the fibrillar tracts distributed throughout it. Let us take any one of the dendrites from the Fig. 6, and trace the lines which represent the fibrillar bundles. In the dendrite (*b*), black continuous lines present the out-going fibrillar bundles, while dotted lines in the same dendrite represent the in-coming fibrillar bundles from other dendrites. If we trace one of the black lines (3), it enters into the dendrites which lie in both sides, and other black lines (1) run toward the nucleus and partially encircle it. The fibrils continue from the nucleus toward the axone and finally enter into the axis cylinder. In the remaining dendrites, the fibrillar tracts are just the same in their distribution with those of dendrites (*b*).

In some cases, the fibrillar bundles which run from the dendrite not only enter into the dendrites which lie nearest on both sides, but they also connect with other dendrites further distant (2). In the cross-section of the cell-body, we notice very often the following appearance: The neighbor-

hood of the nucleus is composed of peculiarly arranged fibrils, forming a "spiral" or "swirl." These appearances are caused by the fibrils, which take very irregular courses and partially encircle the nucleus in a tortuous manner.

III. Finer structure of the ground substance of the spinal ganglion cells in the adult white rat.

It remains to discuss the real nature of the fibrillar structures mentioned above, and to this end the structure of the ground substance of the nerve-cells must first be considered.

Concerning the structure of the ground substance in nerve-cells, two main views are held: the "fibrillar" and "non-fibrillar" structure. The former theory may also be subdivided. One view is represented by the theory of Bethe (*) who regards the ground substance as composed of "Peri Fibrillär Substanz" and "Fibrillen." The so-called Fibrillen are independent individuals distributed throughout the cell-body in a certain way, where they neither anastomose nor branch. Another fibrillar theory is that of Apàthy (1). According to this author, the primitive neurofibrils are to be distinguished by means of special technique, in the nerve-cells as Bethe describes. These fibrils however, are not isolated, but are connected with each other by means of delicate branches, thus forming a very complicated anastomosis within the nerve-cells.

The non-fibrillar theories may also be divided into two groups, represented by the theory of Apàthy (1), Nansen (2), Bütschli (3), etc. Nansen holds the view of primitive tubular structure of the formation of the ground substance of the nerve-cells, that is, the ground substance is entirely composed of extremely small tubules which are directly continuous with the neuraxone.

(*) Bethe, A.—Über die Primitiv Fibrillen in den Ganglien-zellen von Menschen und Wirbelthieren.—Arch. für Mikrosk. Anat., Bd. 51.

(1) Apàthy.—Das leitende Element des Nervensystems, u. s. w.—Mitheil. d. Zoolog. Station zu Neapel, B'd XII, '97.

(2) Nansen, F.—The structure and combination of the histological elements of the central nervous system.—Bergen, '87.

(3) Bütschli.—Investigations on microscopic forms and on protoplasm.—'94. Translation to English.

Bütschli, Held (1), Van Gehuchten (2), Von Lenhossek (3), Ramon y Cajal (4), Marinisco (5), Ewing (6), a. o., hold the view of reticular or spongy formation of the ground substance, stating that the fibrillar structure described by others are not true fibrils but rows of fine granules which form the reticular arrangement of the ground substance.

The writer's observations on this subject are as follows: The ground substance of the spinal ganglion cells of the white rat exhibits a reticular structure as shown in Fig. 7. The meshes of the reticulum are very small but conspicuous. The size and form of the meshes vary. Generally, in the clear zone at the periphery of the cell-body, the meshes are always larger and more conspicuous than in the remaining part. In the neighborhood of the axone hillock the meshes are not only much diminished in size, but also they are much elongated along one axis. Around the nucleus, the meshes reach a minimum size. The form of the reticulum at the periphery shows meshes of a somewhat polygonal shape, but in the remaining part of the cell these meshes are elongated, especially around the nucleus and near the neuraxone. Upon examining with a higher magnification, the protoplasmic threads or filaments which forms the reticulum, we see that it is not smooth but has a somewhat varicose appearance, due to the presence of small bead-like arrangements on the course of the filaments. This bead was called by Held (*) a "neurosome," who discovered the occurrence of the neurosome not only at the connecting point of the net but also inside the net. The writer noticed the occurrence of these structures not only at the connecting points of the net but also in the course of the filament, but could not find them inside the reticulum.

---

(1) Held.—Beiträge zur Strukturen der Nerven-zellen und ihren Fortsätze.—Erste Abhandlung. Arch. für Anat. und Entwickelungs. Anat. Abth., '95.

(2) Van Gehuchten.—Anatomie du systèm nerveux de l'homme.—Lauvain, 1894.

(3) Von Lenhossek.—Feinere Bau des Nervensystems.—'95. P. 147.

(4) Cajal.—Estructura del protoplasma nerviso.—Revista trimestral micrografica, Vol. I, fasc. 1, '96.

(5) Marinisco.—Pathologie gènèrale de la cellule nerveuse.—La Presse Médicale, '97.

(6) Ewing.—Studies on ganglion cells.—Arch. of Neurol. and Psychopathol., Vol. I, No. 3. '98.

(*) Held.—Loc. cit.

This bead or neurosome has peculiar chemical affinities for the staining fluids. Eosin or erythrosin stain this element very deeply, so that it can easily be distinguished from the rest of structures. The fine filament joining these beads seems to be slightly different from the neurosome itself, as is shown by a slightly different staining reaction. It seems, indeed, that these neurosomes are a highly differentiated portion of the protoplasm which forms the reticulum.

The form and size of the neurosomes are different in different localities, as has been already described by Held. These structures are especially numerous within the axone hillock and intracellular extension of the axone. At the periphery of the spinal ganglion cells, the individual meshes of the reticulum are so large that the neurosomes are less crowded, hence, in this region, they are scattered very irregularly. But on the contrary, in the remaining parts of the cell, the meshes of the reticulum are elongated in shape and the rows of neurosomes become more crowded together, thus giving the fibrillar appearence. At first glance, this arrangement of neurosomes looks very much like the fibrils which have been described by many authors. Careful observations, however, show that these lines appearing like fibrils are composed of a row of minute beads arranged serially. Moreover, these pseudo-fibrils are connected by protoplasmic threads, thus forming the reticulum. This structure is shown in Fig. 7. Around the nucleus these neurosomes form somewhat concentric lines in a very beautiful manner. But gradually the figure becomes irregular as the reticulum approaches the periphery. This is the appearance generally found in the spinal ganglion cells. Sometimes the cell shows different arrangement of neurosomes, namely, concentric lines at the periphery but not in the neighborhood of nucleus. Still other variations in arrangement are found.

Graf (*) noticed the fibrils which are composed of a row of minute beads, in the Purkinji cells of human cerebellar cortex. He said: "The cytoplasma show the most beautiful fibrillar structure that I have ever seen. The fibrillæ are

(*) Graf, A.—On the use and properties of a new fixing fluid (chrom-oxalic.)—Bull. of Pathol. Institute of the New York Hospitals, '97. Vol. II, p. 386.

exceedingly fine and are very regularly arranged in the cell-processes and on the surface of the cell, whereas they form a more intricate network in the center of the cell, especially around the nucleus. By closer observation of a favorable spot (the best places are where the stain is not very intensive) we notice that the finest cytoplasmic fibrillæ are not smooth, like smooth muscle fibrils, for instance, but are composed of a row of minute beads closely arranged in single file."

Held believes that the fibrils, according to some investigators, are in reality identical with rows of neurosomes. He hints that some of the fibrils represent bands of neurosomes; other fibrils described by Flemming are bundles of cytospongium.

My own observations support Held's suggestion. My preparations show sometimes exactly the fibrillar structure described by Graf, and I find this condition in the efferent neurones of the Torpedo, as well as in the spinal ganglion cells in the white rat. These fibrils can always be resolved into rows of neurosomes.

Another important point is, that the meshes of the reticulum in the cell-body become more and more elongated toward the axis cylinder. Thus it looks as if the fibrils are radiating from the axone around the nucleus.

The peculiar character of the region from where the axis cylinder originates was first described by Schäffer ([1]).

This region of the cell-body he called the "axone hillock." It is admitted by most investigators that the axone hillock, as well as the axis cylinder, show a parallel arrangement of cytoplasm. The writer notices also these arrangements of fine cytoplasmic threads, which carry the neurosomes, showing a convergent arrangement toward the axis cylinder. In this region the meshes of the reticulum are very small, but careful examination shows that the axone hillock, as well as axis cylinder, are composed of an altered reticulum.

The arrangement of neurosomes, except in the axone hillock, is not the same in all nerve-cells, but differs according to the type of the cells.

(1) Schäffer, K.—Kurze Anmerkung über die Morphologische Differenz des Axen Cylinders in Verhältnisse zu dem Protoplasmatischen Fortsätze bei Nissl's Färbung.—Neurol. Centralbl., Leipzig, Bd. XII, '93, S. 849–851.

In the motor ganglion cells in the anterior horn of the spinal cord, the neurosome presents quite a different arrangement from that of spinal ganglion cells. In the former group the meshes of the reticulum do not show the honey-comb form, but an elongated shape. The cytoplasmic thread carries a great number of neurosomes, which form straight chains. These chains run parallel to the periphery toward the dendrites, as well as toward the axis cylinder. Around the nucleus, however, these chains have the arrangement found in the spinal ganglion cells.

The Purkinjii cells in cerebellar cortex in the white rat show still a different arrangement of neurosomes. In these cells the neurosomes accumulate at the base of the main dendrites, showing very intricate arrangement. But near the entrance of the dendrites the irregular chains rearrange themselves, forming a regular line of neurosomic fibrils. The remaining part of the cell-body show nearly the same arrangement as that of the spinal ganglion cells.

IV.—Remarks concerning the structure of the ground substance in nerve cells.

As has been mentioned already, the ground substance of the spinal ganglion cells of the white rat presents very clearly the reticular structure. This structure, however, is altered by the growth of cell-body; for example, the prolongation of the axis cylinder from the cell-body is accompanied by an elongation of the primitively polygonal meshes of the reticulum, thus giving a fibrillar appearance to the ground substance.

The same holds true in the case of the Torpedo. The apparent fibrils result from alterations in the reticulum, and, therefore, should not be compared to those of Bethe's. Although, in the case of the Torpedo, the reticulum is hard to see, yet it is sometimes clearly demonstrable in thin sections properly stained.

In the spinal ganglion cells of the higher mammalia, except in Dogiel's second type of cells, the cell-body sends off only one prolongation, while in the case of Torpedo, the efferent

neurones of the electric organ give numerous processes from the cell-body. In the former case, the meshes of the reticulum are changed gradually from a regular polygonal form to those much drawn-out in the axone hillock. In the case of the Torpedo, however, the arrangement of the reticulum is modified not only toward the axis cylinder, but in every part of the cell-body from which dendritic processes arise. The appearances in Torpedo can be explained as a result of the growth changes of the cell-body. Judging from what we find in the rat, we assume in the first place the spinal ganglion cell to be a spherical mass filled by the wide meshed reticulum. For the same reason we assume that this spherical mass is pulled out at each point where there is a dendrite, and thus modified as it is where the neuraxone is formed from the axone hillock. As a result, the primitive polygonal meshes are transformed mechanically by the growth changes and thus give rise to the fibrillar appearance. If numerous processes are formed by the cell, as in the case of Torpedo, then the resulting appearance is quite complex. But the principle of its formation is the same as in the more simple spinal ganglion cell. The so-called fibrillar arrangement in the writer's preparation is thus explained:

V.—Summary.

1. The efferent neurones of the electric lobes of *Torpedo occidentalis* present a fibrillar appearance of the ground substance.

2. This appearance, however, is due to an alteration in the shape of the meshes of the reticulum, and, therefore, it cannot be compared with the fibrils described by Bethe, Apàthy, and others.

3. The meshes of the reticulum, which are regarded as the primitive by the present writer, are altered by the growth of the cell-body where the processes, both axone and dendrite, arise and become extremely elongated in these branches.

4. Gradations from the primitive shape of the meshes to the altered form which appears fibrillar, are clearly visible in the spinal ganglion cells of the white rat.

VI.—Illustrations. (Plate I.)

Fig. 1–5—Five serial sections from a single efferent neurone in electric lobe of *Torpedo occidentalis.* Mean diameter of the cell-body ($120\ \mu \times 83\ \mu$); of the nuclei ($37\ \mu \times 34\ \mu$).

Fig. 6—Diagram showing the fibrillar arrangement of the efferent neurone in an electric lobe of *Torpedo occidentalis.*

Fig. 7—Spinal ganglion cell from the mid-cervical ganglia of the adult white rat. Cell-body ($41\ \mu \times 30\ \mu$); nucleus ($15\ \mu \times 15\ \mu$).

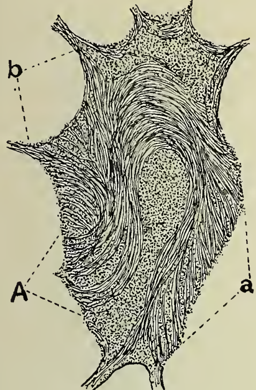

Fig. 1.

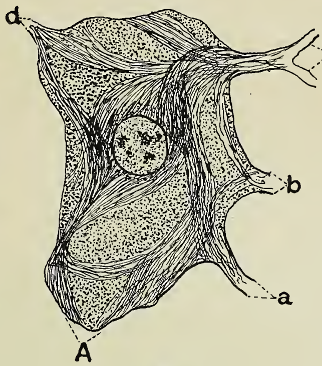

Fig. 2.

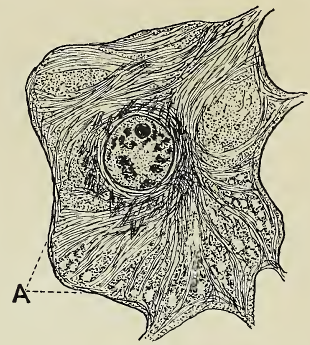

Fig. 3.

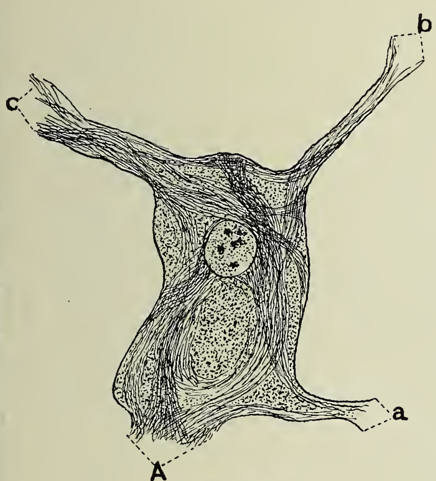

Fig. 4.

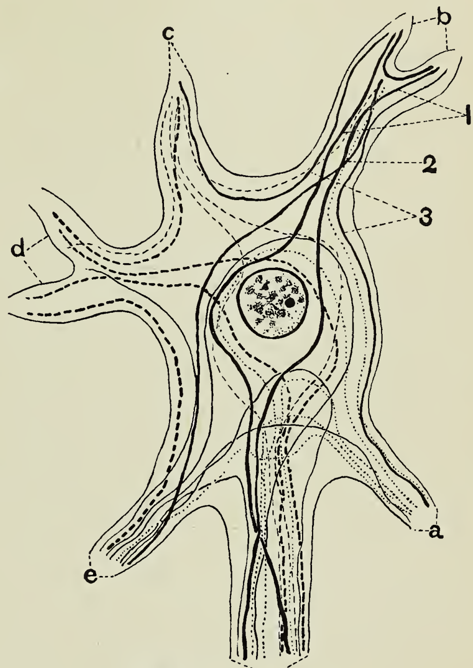

Fig. 6.

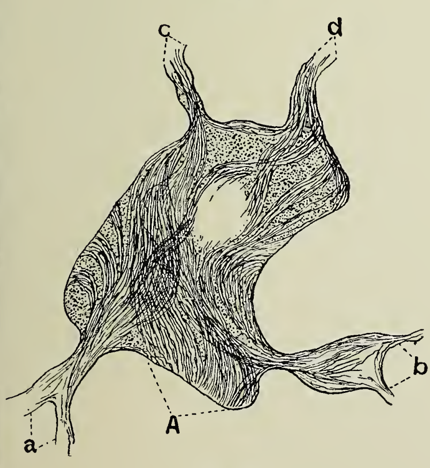

Fig. 5.

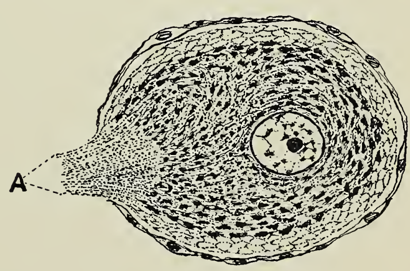

Fig. 7.